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TITLE: Power amplifier having negative feedback circuit for transmitter

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INVENTOR-INFORMATION:

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US-CL-CURRENT: 330/10; 330/107 ; 332/103 ; 455/126

ABSTRACT:

Power amplifier circuit incorporating a negative feedback circuit for a transmitter and phase control method therefor. An I-component test signal and an I-component baseband feedback signal are added for generating an I-component summing signal. A Q-component test signal and a Q-component baseband feedback signal are added for generating a Q-component summing signal. A carrier is orthogonally modulated with the I- and Q-component summing signals. A part of the modulated signal is orthogonally demodulated with the carrier, whereby I-component baseband feedback signal and Q-component baseband feedback signal are outputted. Phase of the carrier is changed in accordance with a phase control signal for holding the phase of the carrier at a time when the detected state of one of the i- and Q-component summing signals as selected meets predetermined condition.

11 Claims, 12 Drawing figures

Exemplary Claim Number: 1

Number of Drawing Sheets: 10

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Brief Summary Text - BSTX:

In radio systems in which a linear digital modulation system such as, for example, 16QAM (Quadrature Amplitude Modulation), .pi./4 shift QPSK (Quadrature Phase Shift Keying) or the like is employed, it is indispensably required to compensate for nonlinear distortion of a power amplifier. To this end, a variety of nonlinear distortion compensating systems (linearizers) are proposed for practical application. Among them, a Cartesian loop negative feedback type linearizer has been conventionally employed long since. For having better understanding of the background techniques of the present invention, description will first be made in some detail of the conventional linear feedback amplifier known heretofore by reference to FIG. 2 which is a block diagram showing an arrangement of a transmitting section of a digital radio system provided with a Cartesian loop negative feedback type linearizer.

Brief Summary Text - BSTX:

In this state, in the baseband signal generator 1, a predetermined DC voltage is given to only the I-component for the purpose of phase adjustment while the Q-component being held zero (Q=0), whereon the quadrature modulation is carried out straightforwardly for signal transmission by way of the antenna 9 in accordance with the procedure described previously. In that case, the output waveform of the amplifying circuit 8 assumes the waveform of the non-modulated carrier signal. Such being the circumstances, when a part of the output of the amplifying circuit 8 is fed back by way of the directivity coupler 10, then the DC voltage makes appearance only for the I-component of the feedback signal outputted from the quadrature demodulator 16 while no DC voltage makes appearance for the Q-component so long as the feedback signals i and q outputted from the quadrature demodulator 16 are in phase with each other. By contrast, when the output signals i and q of the quadrature demodulator 16 are out of phase with each other, a DC voltage corresponding to the phase deviation between these output signals appears on the side of the Q-component. Thus, the angle of rotation corresponding to the phase deviation can be determined on the

basis of the DC voltages of the I-component and the Q-component.

Brief Summary Text - BSTX:

In a preferred mode for carrying out the phase control method according to the present invention, DC voltages differing each other may be used as the I-component test signal and the Q-component test signal, respectively. By way of example, the DC voltages which satisfy the conditions that I=1 and Q=0 in an I-Q orthogonal coordinate system can be employed as the I- and Q-baseband signal inputs, respectively. The voltage value of either the I-component signal or the Q-component signal inputted to the quadrature modulator is compared with a reference voltage value (which meets the conditions that I=0 and that Q=0) in the course of rotating the phase of the carrier signal clockwise or counterclockwise in the I-Q orthogonal coordinate system, to thereby acquire a polarity signal which can assume positive (plus) polarity or negative (minus) polarity. By detecting the time point at which the polarity signal changes from the plus to minus polarity or vice versa (i.e., the time point when the conditions that I=1 and that Q=0 are met), it is possible to detect the point at which the phases of the input I- and Q-component signals coincide with those of the feedback signals, respectively.

Detailed Description Text - DETX:

The phase shifter 18' adjusts or shifts the phase of a carrier signal LO1 supplied from the first PLL frequency synthesizer 12 in conformance with a phase control signal supplied from the phase controller 17. The phase-adjusted carrier signal is supplied to the quadrature demodulator 16. The phase control signal outputted from the phase controller 17 indicates the DC voltage of the I- and Q-components for realizing the desired phase value.

Detailed Description Text - DETX:

More specifically, the voltage value of either one of the I-component signal and the Q-component signal inputted to the quadrature modulator 4 is compared

with the reference voltage value of 2.5 V (on the conditions that I=0 and that Q=0) by means of a comparator (described later on) while rotating the phase of the carrier signal LO1 clockwise or counterclockwise on a 30.degree.-by-30.degree. basis in the I-Q orthogonal coordinate system, to thereby derive a polarity signal indicative of positive (plus) polarity or negative (minus) polarity in dependence on the result of the comparison. In this case, by detecting the time point at which the polarity signal changes from plus to minus polarity or vice versa (i.e., at the time point when the conditions that I=1 and that Q=0 is satisfied, to say in another way), it is possible to detect the point at which the phase of the input I-/Q-component signal coincides with that of the feedback signal.

Detailed Description Text - DETX:

In more concrete, unless the phase deviation of the feedback signal takes place when the test signals I=3 V (volts) and Q=2.5 V (volts) are supplied to the feedback loop, this corresponds to the case illustrated in FIG. 3 at (1) where I=1 and Q=0 in the I-Q orthogonal coordinate system. By comparing the voltage value of the Q-component signal Q' inputted to the quadrature modulator with the reference voltage of 2.5 volts (satisfying the conditions that I=0 and Q=0) while rotating successively or sequentially the phase of the carrier signal LO1 counterclockwise on a 30.degree.-by-30.degree. basis (i.e., by 30.degree. incrementally or stepwise) in the I-Q orthogonal coordinate system, the plus (+) polarity signal is obtained when the voltage value of the Q-component signal Q' is higher than 2.5 volts whereas the minus (-) polarity signal is obtained when the voltage value of the Q-component signal Q' is lower than 2.5 volts. In the negative feedback amplifier according to the instant embodiment of the invention, change of the polarity signal from minus (-) polarity to plus (+) polarity means that the Q-component signal Q' passes through the point where I=1 and Q=0. Detection of this point by means of the phase controller 17 indicates that there exists a point at which the phases of the input

signals of the I-component and the Q-component coincide with the phases of the corresponding feedback signals.

Detailed Description Text - DETX:

The phase controller 17 generates DC voltages for the I-component and the Q-component which are phase control signals supplied to the phase shifter 18'. The control circuit 54 is so designed as to generate a digital signal for changing or shifting the phase angle (30.degree. by 30.degree. in the illustrated case, i.e. coarse regulating operation) on the basis of the contents of the data table shown in FIGS. 10A-10B. The D/A converters 55-1 and 55-2 cooperate to set the DC analog voltage such that the initial phase assumes the phase angle designated by the control signal.

Detailed Description Text - DETX:

Further, in the negative feedback amplifier described above, the DC voltages of I=3.0 volts and Q=2.5 volts are outputted from the baseband signal generator 1, wherein the Q-output component Q' of the loop filter 3-2 is checked or monitored. However, such arrangement may equally be adopted that the DC voltages I=2.5 volts and Q=3.0 volts are outputted from the baseband signal generator 1, wherein the I-output component I' of the loop filter 3-1 is monitored by the phase controller 17. Besides, it can readily be appreciated that every time the phase shifting rate is changed, the Q-output component signal Q' or alternatively the I-output component signal I' may be checked or monitored without departing from the spirit and scope of the present invention.

Claims Text - CLTX:

6. A power amplifier circuit according to claim 1, wherein said I-component test signal and said Q-component test signal are DC voltage signals of values differing from each other.

Claims Text - CLTX:

decision means for making decision whether or not one of said

I-component and
Q-component summing signals exceeds a predetermined voltage, and

Claims Text - CLTX:

inhibit means for invalidating the output signal of said comparator when one of said I-component and Q-component summing signals exceeds said predetermined voltage range.